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Virginia Pollinator-Smart Solar Industry

POLLINATOR–SMART
Monitoring Plan

Virginia Department of Conservation & Recreation

Virginia Department of Environmental Quality

On-site Monitoring Guidance for Pollinator-Smart/Bird Habitat Solar Facilities in Virginia

At a Glance...

This document outlines the recommended monitoring procedures for assessing "Pollinator-Smart" solar facilities in Virginia.

A Pollinator-Smart solar facility is one that meets performance standards established in the Virginia Pollinator-Smart Solar Industry program ("Pollinator-Smart program"), with joint oversight from the Virginia Department of Environmental Quality (DEQ) and the Virginia Department of Conservation and Recreation (DCR).

Performance standards are given in the most current version of the Established Solar Sites Virginia Pollinator Smart/Bird Habitat Scorecard, ("Scorecard"), and monitoring data will be collected on established solar sites to determine continued compliance with Pollinator-Smart performance standards. This includes sites that were either: 1) established as approved Pollinator-Smart solar facilities when constructed; or, 2) retrofitted as approved Pollinator-Smart solar facilities. The approval process is outlined in the **Virginia Pollinator-Smart Solar Industry Comprehensive Manual**. In all cases, for new sites or retrofits the mode of entry for the Pollinator-Smart program is the **Proposed or Retrofit Solar Sites Scorecard**; likewise, for established sites, the test for continued compliance with the Pollinator-Smart program is the **Established Solar Sites Scorecard**.

At a minimum, the following data will need to be collected on established sites in order to complete the Established Solar Sites Scorecard:

1. **Vegetation Monitoring**
   a. Identity, species richness, percent cover, and reproductive phenology of plant species from vegetation sampling plots within each of the planting zones on-site
      ii. Panel Zone
      iii. Open Area
      iv. Screening Area
2. **Site Management Monitoring**
   a. Documentation of management activities and planning-level documents completed to promote Pollinator-Smart habitats on-site
      ii. Planning and Maintenance
         1. Vegetation Management Plan
         2. Annual vegetation monitoring
         3. Annual invasive species mapping and control efforts
         4. Banned use of insecticides on-site
      iii. Invasive Species Cover
         1. Percent of site covered with tall fescue
         2. Percent of site covered with listed invasive species
      iv. Public Engagement and Research
         1. Signage, educational displays and benches
         2. Research collaboration with institution
      v. Pollinator Habitat Features
         1. Ground-nesting bee habitat
         2. Edge habitat in with flowering native species
         3. Cavity nesting sites
         4. Constructed pollinator/bird nesting habitat
         5. On-site wetlands or water source(s)

A site that continues to meet the standards for a Pollinator-Smart solar facility in Virginia will be vegetated with a predominance of native species listed on the Solar Site Native Plant Finder and will have adequate documentation of site management activities focused on pollinator habitat.

Reporting requirements are minimal and include the following baseline components: executive summary; site map; vegetation data tables; representative photographs; and, site management documentation.

Table of Contents

Definitions

The Pollinator-Smart program employs a set of terms, methods, and plans that are specific to the solar industry in Virginia. A detailed list of definitions is provided in the Comprehensive Manual; however, there are certain terms used throughout this Monitoring Plan that merit definition because of their unique relevance to the Scorecard. For convenience, definitions for these terms are provided below:

Open Area: Any area beyond the panel zone, within the property boundary.

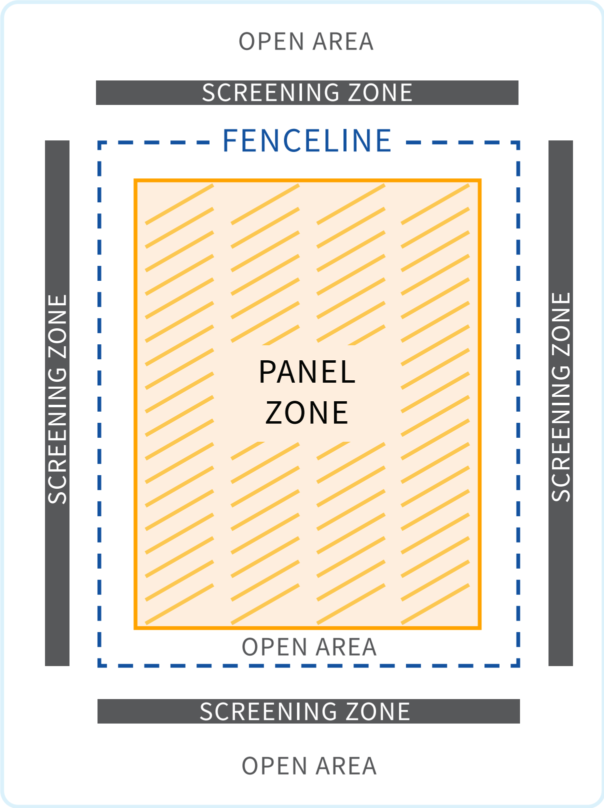
Panel Zone: The area underneath the solar arrays, including inter-row spacing.

Screening Zone: A vegetated visual barrier.

Qualified Professional: A person trained in plant identification, vegetation sampling, and vegetation assessment techniques.

Solar Native Plant Finder: The Virginia Solar Site Native Plant Finder, an online research tool developed by the DCR Natural Heritage Program (link).

Used by Pollinators: Plant species with a "pollinator" designation on the Virginia Solar Site Native Plant Finder.



Introduction

The Virginia Department of Environmental Quality (DEQ) and Department of Conservation and Recreation (DCR) have developed an ecologically-responsible program to encourage pollinator-smart solar energy developments throughout the Commonwealth of Virginia. The program is referred to as the **Virginia Pollinator-Smart Solar Industry** (paraphrased hereafter as "Pollinator-Smart program"), and its overall motivation and purpose are described in detail in the Virginia Pollinator-Smart Solar Industry Comprehensive Manual ("Comprehensive Manual"). For a more concise description, readers can visit the program website at Virginia's Pollinator-Smart Solar Portal.

In Virginia, a "Pollinator-Smart" solar facility is one that meets the goals and objectives of the Pollinator-Smart program. This determination is made through completion of the Virginia Pollinator Smart/Bird Habitat Scorecard ("**Scorecard**"), and the Scorecard also serves as the program's mode-of-entry for solar facilities. Details surrounding the Scorecard concept, including its inception and use in the solar industry, the science behind its development, the states that pioneered its use and functionality, and Virginia's approach to the concept, are provided in the Comprehensive Manual.

Virginia has established two versions of the Scorecard to be used in the following scenarios:

Proposed of Retrofit Solar Sites (Version 2.0a)– New solar facilities planned as Pollinator-Smart sites, or existing solar facilities planned to be retrofitted as Pollinator-Smart sites (link)

Established Solar Sites (Version 2.0b)– Established solar facilities already approved as Pollinator-Smart sites and being monitored for continued compliance with the Pollinator-Smart program (link)

For the purposes of determining compliance with performance standards, *established sites that have already been designated as Pollinator-Smart must be monitored using methods that will document site-specific conditions and generate the data required to complete the Established Solar Sites Scorecard*. This report outlines the recommended procedures for accomplishing this task in a given monitoring year.

The conceptual framework for the monitoring approach described herein was developed with four concurrent goals in mind: 1) ease of use; 2) repeatability; 3) scientific validity; and, 4) consistency with ecological sampling practice. Other state programs were consulted for general concepts, and these are outlined in the Comprehensive Manual. For field methods specific to documenting vegetation composition and relative dominance, ideas from existing programs within the State of Virginia were incorporated (notably, the DCR Natural Communities of Virginia, the "Mitigation Banking Instrument Template" jointly authored by DEQ and the U.S. Army Corps of Engineers, Norfolk District, and the DCR Rapid Assessment Field Survey for Ecological Community Groups within Proposed Wind Energy Project Areas). Other references used to develop practical monitoring concepts and procedures are cited where appropriate below.

Performance Standards

For *established sites that are being monitored to determine compliance with the Pollinator-Smart program*, ten performance metrics are rated in accordance with the most current version of the Established Solar Sites Scorecard as outlined below. Six of the metrics evaluate establishment of native vegetation communities, and four metrics evaluate site management practices that affect pollinator habitat.

VEGETATION METRICS

PANEL ZONE

1. Percent of overall existing cover in the panel zone vegetated with Solar Native Plant Finder species (15 points total)
2. Native grass diversity in panel zone (5 points total)

OPEN AREA

3. Percent of overall existing cover within the open area vegetated with Solar Native Plant Finder species that are used by pollinators (15 points total)
4. Total number of Solar Native Plant Finder species found within the open area (15 points total)
5. Within the open area, seasons with at least three (3) Solar Native Plant Finder species in flower (10 points total)

SCREENING ZONE

6. Percent of overall existing cover in the screening area vegetated with Solar Native Plant Finder species (15 points total)

SITE MANAGEMENT METRICS

PLANNING AND MAINTENANCE

7. Site planning and maintenance practices (25 points total)

INVASIVE SPECIES COVER

8. Invasive species risk (-20 points total)

PUBLIC ENGAGEMENT AND RESEARCH

9. Public engagement and research (10 points total)

POLLINATOR HABITAT FEATURES

10. Pollinator/bird nesting habitat on-site (20+ points total)

For facilities already established as Pollinator-Smart sites, performance standards are set by the overall score on the most current version of the Established Solar Sites Scorecard. **A minimum score of 80 must be achieved for a Pollinator-Smart designation, and 100+ points must be reached for Gold Certification.**

Monitoring Methods

The recommended methodology described below will provide the data necessary to fill out the Established Solar Sites Scorecard in a given monitoring year. Methods are divided into two categories: 1) vegetation monitoring; and, 2) site management monitoring. The approaches described under vegetation monitoring are based on existing programs within the Commonwealth as well as ecological sampling principles for vegetation assessment from the scientific literature. The approaches provided for site management involve adequate documentation of re-vegetation management practices used on-site throughout the year.

SAMPLING DESIGN

VEGETATION MONITORING

1 DETERMINE SIZE OF SAMPLING PLOTS

In Herbaceous Habitats: One of the most commonly used plot sizes in herbaceous community sampling is the 1 m^2 (10.8 ft^2) square sampling frame (Mueller-Dombois and Ellenberg 1974, Krebs 1999, Kindt and Coe 2005), although a variety of plot sizes and shapes may be used to assess herbaceous vegetation (Mueller-Dombois and Ellenberg 1974, Krebs 1999). One concern is that the use of smaller plot sizes on larger sites risks higher sample variances, perhaps to the point that an excessively large number of plots would need to be sampled to capture the overall community variability and minimize sample error (Krebs 1999). Alternatively, use of larger plots sizes could minimize this effect with fewer plots, but would require longer search times to adequately evaluate all species within the plot (Kenkel et al. 1989, Kenkel and Podani 1991). For this reason, vegetation ecologists over the years have sought a tradeoff between high variance for small plots and longer sampling times for larger plots. Based on the literature, the **1 m^2 (10.8 ft^2) square quadrat** represents a reasonable compromise for **herbaceous communities**, allowing for cover estimates to be evaluated relatively quickly in the field and still maintain statistical rigor.

In Forested or Scrub-shrub Habitats: In cases where the area is dominated by forested or scrub-shrub species (most often, this will be encountered in the screening zone), larger plots will need to be sampled to assess the additional structural complexity of the community. For **forested or scrub-shrub sampling** in the open area or screening zone, a plot size of **100 m^2 (1076 ft^2)** is recommended based on the standardization of this size in accepted protocols such as the North Carolina Vegetation Survey (Peet et al. 1998) and the National Wetland Condition Assessment (USEPA 2016). In terms of sampling efficiency for woody species (trees and shrubs/saplings), **circular plots** are easiest to lay out in the field (only one reference point is needed at the center), and circles minimize the number of edge decisions because they have the lowest perimeter-to-area ratio. The **radius** for a 100 m^2 (1076 ft^2) circle would be approximately **5.6 m (18.5 ft)**. While a circular plot is the preferred sampling method, if the area to be sampled is not wide enough to accommodate a 37-foot-wide circle, then the plot can be modified into a rectangular shape as long as it still encompasses a 100 m^2 area.

RECOMMENDED PLOT SIZES

Herbaceous Plots: 1 m^2 (10.8 ft^2) quadrat

Woody Plots: 5.6 m (18.5 ft) radius circular plots

2 DETERMINE NUMBER OF SAMPLING PLOTS

To initiate sampling, qualified professionals conducting the sampling must determine *a minimum number of plots* that will provide an initial sample upon which to evaluate sample adequacy (see Step 5 below). Several authors recommend establishing a minimum sample area as a baseline for determining initial plot number (Mueller-Dombois and Ellenberg 1974, Krebs 1999, Gardener 2017).

In Herbaceous Habitats: For homogeneous cover types, the minimum sample area recommended for herbaceous communities is 25 m^2, or 25 plots at 1m^2 per plot (Mueller-Dombois and Ellenberg 1974). This density would likely result in oversampling for smaller sites (e.g., < 5ac); therefore, a recommended plot density for smaller sites is to sample **5 plots per acre for sites up to 5 acres** in size. At this point, the 25 m^2 minimum sample area is achieved. Provided that the sample effort does not cross a community boundary, **25 plots should provide a baseline sample for homogeneous cover types of any size greater than 5 acres**, at which time the data should be evaluated to confirm sample adequacy and determine if additional sampling is needed (see Step 5 below). A list of minimum plots per acre of sample area is provided in Table 1.

Table 1. Minimum number of plots per herbaceous sample area size.

Sample Area (ac.)	Number of Plots
1	5
2	10
3	15
4	20
5+	25

In Forested or Scrub-shrub Habitats: The minimum sample area recommendations for forests is around 500 m^2 (Mueller-Dombois and Ellenberg 1974). At a plot size of 100 m^2, this equates to 1 plot per acre up to 5 acres, at which point the recommended minimum sample area of 500 m^2 is achieved, and the data collected can be assessed to confirm sample adequacy and determine if additional sampling is required (see Step 5 below).

3 DETERMINE LOCATION OF SAMPLING PLOTS

The recommended technique for vegetation monitoring is to use a stratified-random approach. A stratified-random sampling design is one in which the study area is divided into a number of non-overlapping subdivisions (or strata) and samples are randomly selected from each subdivision (Manly 2015, Henderson and Southwood 2016). The benefit of this approach is that investigators are able to sample the plant community in a non-biased manner (due to the randomization component) while also ensuring that the sampling effort adequately covers the entire study site (due to the stratification component) (Mueller-Dombois and Ellenberg 1974, Tiner 1999, Henderson and Southwood 2016).

SAMPLING DEFINED, SAMPLE UNITS, AND ECOLOGICAL SAMPLING THEORY

For most scientific measurements of vegetation communities, a sample is defined as a collection of sample units (SU), the latter of which can be defined as discrete portions of an aggregate (i.e., community) from which repeatable observations can be made (Pielou 1984, Ludwig and Reynolds 1988, Krebs 1999). Sampling is therefore defined as the collection and analysis of data from SUs to make informed assumptions about the overall community (Ludwig and Reynolds 1988).

Ultimately, the purpose of sampling vegetation communities is to develop summary data about the sample based on statistics calculated from measurements or observations of the SUs (e.g., "central-tendency" statistics like arithmetic mean, etc.). Although these summary data represent the sample, they are assumed to also be representative of the overall community as long as certain assumptions of ecological sampling theory are upheld. The most important of these are listed below (Krebs 1999):

1. All SUs should have an equal chance of being selected.
2. The sample (collection of SUs) should not cross community boundaries (i.e., the sample should be taken from a relatively homogeneous cover type).
3. Sample adequacy should be demonstrated (see discussion below).

If the above assumptions are met, a sample (and its associated statistical derivations) can be said to represent the underlying community with respect to the measurements or observations collected in the field. Vegetation sampling strategies are conformable to the above criteria as long as locations of SUs are randomized, the site is "stratified" (i.e., divided) by planting zone or community type with respect to sample area (see Stratification), and sample adequacy is evaluated via the species-area relationship or equivalent technique (see discussion below).

STRATIFICATION

Using a stratified-random sampling technique on Pollinator-Smart solar sites in Virginia, sites are initially divided into the three zones based on the definitions provided above: panel zone, transition zone, and screening zone. Each zone will be considered one "sample area," but zones may be further subdivided into unique community types if necessary (see discussion on sample adequacy in Step 5 below).

Plot locations are then determined using a randomization approach. Examples of randomization procedures are provided below.

Randomization Procedure #1 – Baseline/ Transect Approach

1. Within each sample area, establish a baseline along one edge. Subdivide the baseline into equal segments (a second "stratification"). The segments may be any size but should be spaced in a manner that will allow the minimum number of plots to be sampled (see discussion on minimum plot number below), taking into account the plot size and shape.
2. Within each segment, locate a single random point along the baseline. Random points are determined using a random numbers generator and setting the minimum value at 1 and the maximum value at the overall length of the segment.
3. From the random baseline point within each segment, establish a sampling transect perpendicular to the baseline extending across the width of the sample area.
4. Along each transect within each segment, determine the locations of sampling plots using the same randomization procedure described above but taking the overall transect length as the maximum value for the random numbers generator. The number of plots per transect will vary depending on the overall length of each transect and the total minimum number of plots required for the site.

Randomization Procedure #2 – GIS

1. Once the site has been stratified into separate vegetation zones, most GIS-based applications have a random point generator function that allows users to establish a pre-determined number of random points within a polygon or

feature in GIS. Taking this approach, determine the number of points needed within each zone (stratum) and have the GIS application randomly select locations for the points.

2. The GIS technique carries the risk that the randomization procedure will inadvertently cluster sampling points without having plots "spread out" across the zone as in the baseline/transect approach above. One solution to this problem is to subdivide the zone into equal segments as describe above and subject each segment to the GIS random point routine.

Using either approach outlined above, investigators can complete a desktop assignment of random plots within a selected area prior to fieldwork. This information can be incorporated into a data collection platform using mobile technology coupled with GPS receivers, which can then be used to wayfind to the location of each point while sampling. This type of approach allows investigators to accommodate a stratified-random sampling design while alleviating the need to lay out baselines and transects. An example of a stratified-random approach is provided in Appendix A.

Once the plots have been laid out, sampling proceeds based on a predetermined minimum plot density, and sample adequacy is assessed (see Step 5 below). If the sample for each zone is determined to be inadequate, plots are added until sample adequacy is achieved.

4 SAMPLE EACH PLOT

TIMING OF YEAR AND SAMPLING LEVEL-OF-EFFORT

It is recommended that vegetation sampling be performed during peak growing season, which corresponds to the mid- to late-summer months in the mid-Atlantic region (DeBerry and Perry 2004).

The benefit of a peak growing season sampling window is that it allows reviewers to observe the site when aboveground biomass accumulation and plant species richness are expected to be highest. One concern is that certain spring-flowering species could be missed during a mid- to late-summer site visit; however, in most cases, early flowering species are identifiable from vegetative organs (e.g., leaves, stems, roots), and many of Virginia's spring-flowering species have persistent fruits that may be used for identification later in the summer (Weakley et al. 2012).

Using the 1 m^2 plot size in combination with a cover class scale, the average time to estimate cover for all species within a plot should be less than 10 minutes, which would allow a professional to complete approximately 6+ plots per hour or around 50 plots per day. In addition, experience has shown that even though the woody species plots are larger, the time investment is approximately the same. Alternatively, we estimate that a team of two or more professionals could increase sampling efficiency by 25-50%.

VEGETATION MONITORING

All species present within plots should be identified to species level (or subspecific taxon, if applicable). It is recommended that species nomenclature follow the *Flora of Virginia* (Weakley et al. 2012), the most current version of which is accessible via the Flora of Virginia App. For each species in the plot, **percent cover** will be estimated and recorded. For this purpose, a **cover class scale** is recommended, because it allows percent cover to be estimated based on ranges of cover values that are easily perceived in the context of a square herbaceous plot or a circular woody species plot. Using this approach, the midpoints of the classes are recorded for analysis (for non-integer midpoints, cover classes are rounded to the nearest whole integer). **Cover estimates are then averaged across the zone** to develop relative cover values (i.e., the percentage of the total cover across the entire zone that each species comprises; see example,

Appendix C). Once this is calculated, questions on the scorecard that relate directly to percentage may be answered based on the composition of the species and the relative cover values. Qualified professionals conducting the analysis should also treat any area of exposed soil within the plot as “bare ground” and assign a cover value.

A simple cover class scale that would be appropriate for herbaceous vegetation is shown in Table 2 below.

Table 2. Modified Daubenmire Cover Class Scale (Mueller-Dombois and Ellenberg 1974).

Cover Class ID	Percent Cover Range (%)	Cover Class Midpoint (%)
1	0-1%	1
2	1-5%	3
3	5-25%	15
4	25-50%	38
5	50-75%	63
6	75-95%	85
7	95-100%	98

In addition to species identification, plot cover estimates, and relative cover calculations, qualified professionals conducting the sampling will need to document the following characteristics of each species encountered on-site in order to complete the vegetation community questions on the Scorecard:

1. Virginia Solar Site Native Plant Finder classification status, if applicable (i.e., pollinator species, warm-season grass, etc.);
2. native/non-native status;
3. invasive/nuisance species status; and,
4. reproductive phenology (seasonal timing of flowering).

Information on all of these characteristics is anticipated to be made available on the Solar Native Plant Finder, with portions currently under development. Solar Native Plant Finder classification status is already available online. Native/non-native status (and species-by-county distribution) can also be found in the Flora of Virginia (available hard copy or digital app) or on the Digital Atlas of the Virginia Flora. A list of invasive species that occur in Virginia is provided on the Virginia Natural Heritage Program website. Reproductive phenology is in the Flora of Virginia. For ease of use, a Virginia Pollinator-Smart Rapid Assessment Form has been developed and is available in Appendix B. In addition, an example of a completed vegetation data table is provided in Appendix C.

5 CONFIRM SAMPLING ADEQUACY HAS BEEN REACHED

Once the initial plot sampling has been completed, sample adequacy should be evaluated using an approach that demonstrates adequate coverage of the vegetative community. Sample adequacy is most frequently evaluated using the species-area relationship (Scheiner 2003), though other methods can be used (e.g., standard error ≤ 10% of the mean, McCune and Grace 2002). In species-area analyses, the cumulative total number of species is tracked as plots are sampled, and professionals conducting the sampling develop a graph with cumulative species richness (total number of species) on the Y-axis and cumulative area sampled on the X-axis (which can be approximated by cumulative number of plots). The curve generated by this approach is an example of a “**species-area curve**,” and it is considered to be stabilized when the curve flattens out toward the top right-hand side (as if to approach an upper asymptote). In practice, the inflection point of the curve is used to approximate an adequate sample size for vegetation research (McCune and Grace 2002). During sampling, scientists create a species-

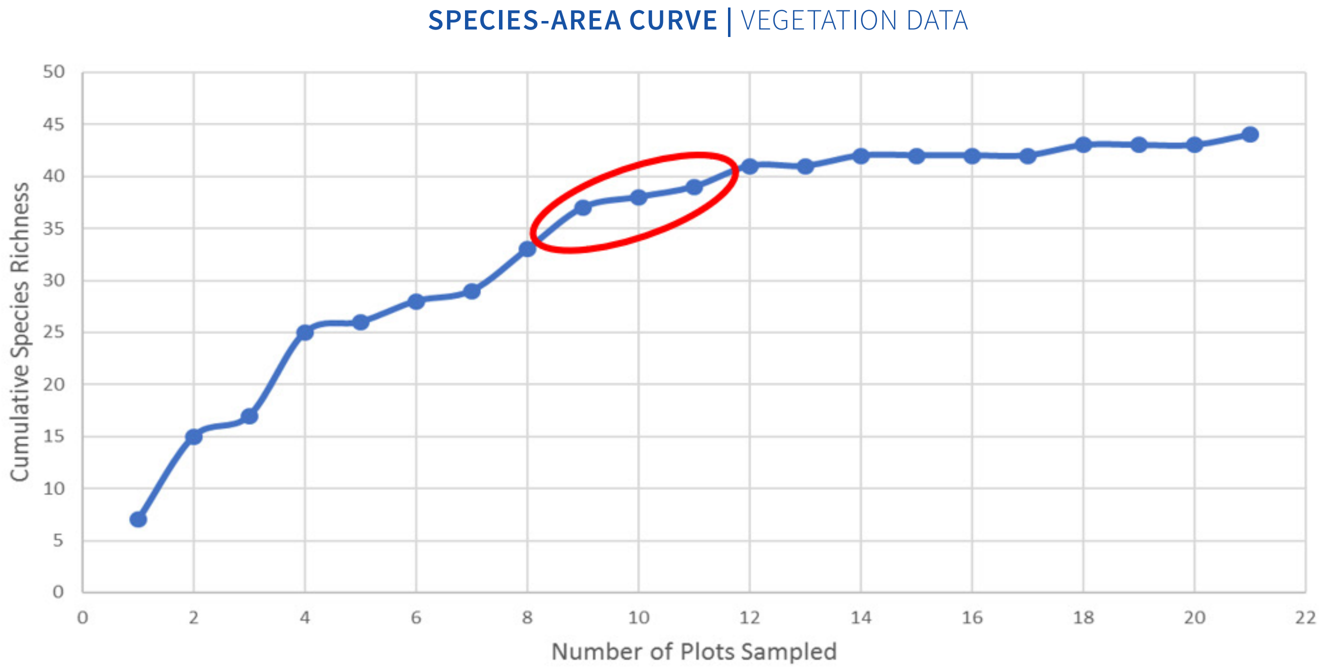


Figure 1. Species-area curve plotted on a simple line graph with markers created in Excel. This graph is easily interpreted as leveling off in the upper half, suggesting that a sample size of 9-11 plots represents the minimum adequate number of sample units for this site (corresponding to the inflection point on the graph shown by the red circle).

area curve after the initial sampling effort (the initial number of plots can be estimated from the literature; see Initial Plot Density below). By entering cumulative species richness and plot number into a simple graphing program (Excel, etc.), a species-area curve can be generated "on the fly" as a simple scatterplot/trendline graph and interpreted in the field, and scientists can add plots as necessary until the curve stabilizes. An example of a species-area curve generated for data collected on a mid-Atlantic region native meadow restoration project is shown in Figure 1.

If the Curve Doesn't Stabilize: On sites with high species richness, it is possible that the species-area curve will not flatten out to the right after completing the minimum number of sample plots. When this occurs, random plots should be added to each stratum (zone or subdivision) until the curve levels off.

"Stairstep" Curves: In other cases, the species-area curve may produce a "stairstep" pattern such as the one show in Figure 2. A stairstep pattern typically means that the species-area phenomenon has been tracked across community boundaries. When this occurs, professionals conducting the sampling should re-stratify the site into discrete, homogeneous cover types and re-sample using the stratified-random approach described above. In most cases, plots already sampled may be retained in the data sets for the remapped community types.

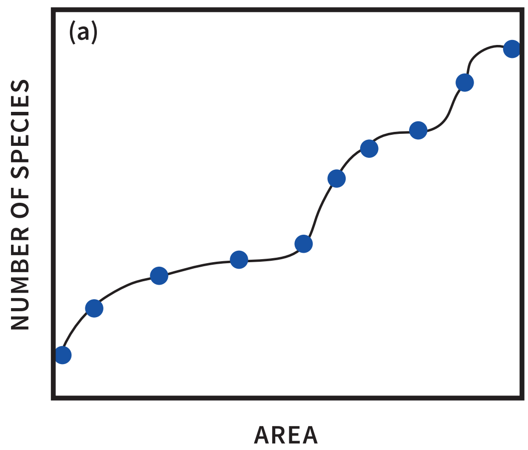


Figure 2: "Stairstep" species-area curve. From Scheiner (2003).

6 ESTABLISH PERMANENT PHOTO STATIONS AND PHOTO-DOCUMENT SITE

Permanent photostations should be established within each of the three zones, and representative photographs of the developing vegetation should be taken in each monitoring year. For smaller vegetation zones, one photostation per acre is recommended up to 5 acres. For larger zones, a minimum of five photostations should be established across the zone, distributed in a manner that will allow adequate spatial coverage. Photographs should be taken from the same height and direction for year-to-year comparisons.

7 CONDUCT SITE MANAGEMENT MONITORING

Most of the site management documentation required to complete the Established Solar Sites Scorecard can be compiled as management activities are completed on-site. Records and photographic evidence of the re-vegetation implementation sequence including site prep, initial planting, supplemental overseeding, habitat enhancement, public engagement and research, and invasive or nuisance species management can be recorded in the form of activity logs and/or site photographs. These documents can be sourced from the planting contractor, the solar site manager, or an environmental consultant.

8 MAP INVASIVE AND/OR NUISANCE SPECIES

In addition to site management documentation, invasive and/or nuisance species mapping is recommended annually. This includes documenting any dominant zones of non-native invasive species listed on the Virginia Invasive Plant Species List (Heffernan et al. 2014), as well as zones of any nuisance species identified in Table 3 below. The distribution of invasive/nuisance species should be shown on a scaled, spatially-correct plan view map of the site, with the total area for each species expressed in acres and percentage of the total study area.

Table 3. Nuisance Species Not on Virginia Invasive Plant Species List

TABLE UNDER DEVELOPMENT

Reporting

Because the site-level documentation described in this monitoring plan is ultimately intended to support completion of the Established Solar Sites Scorecard, reporting should be considered supplemental information to the Scorecard and should be concise and easily searchable. The format presented in Appendix C is recommended for the vegetation data. At a minimum, the report should include:

- ☑ **Executive Summary** — Short (1-page) narrative summarizing monitoring results
- ☑ **Map** — Scaled, spatially-correct plan view of the site showing the following:
  - » Project boundary
  - » Vegetation zones (acres identified)
  - » Vegetation plot locations (including transects, if used in plot layout)
  - » Permanent photostations
  - » Invasive/nuisance species polygons (acres and percentage identified)
  - » Pollinator habitat features (if relevant)
- ☑ **Vegetation data** — Presented in tabular format
- ☑ **Representative photographs**
- ☑ **Site management documentation**

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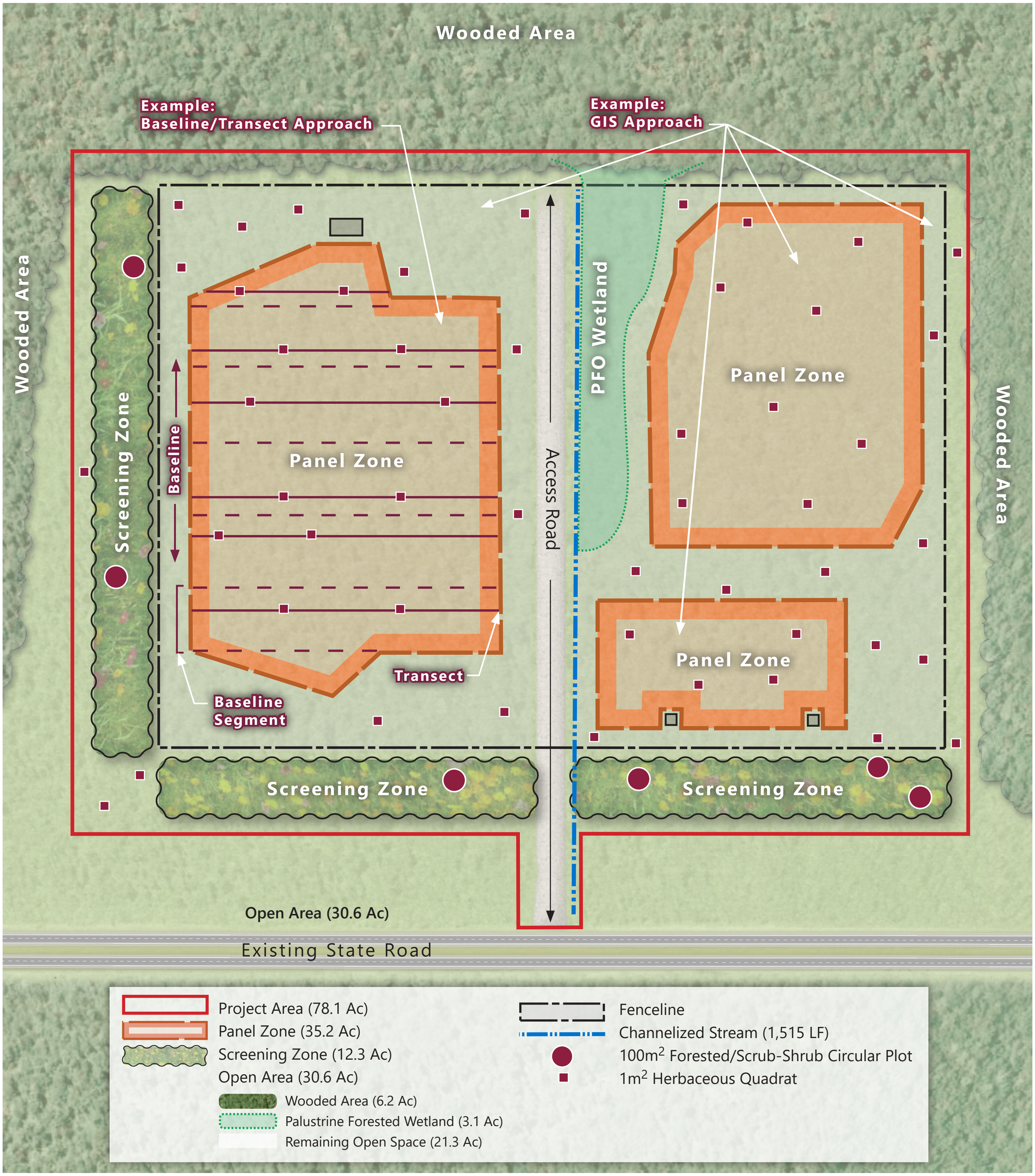
Appendix A

Example of Stratified-Random Study Design

Virginia Pollinator-Smart Solar Industry

EXAMPLE OF STRATIFIED-RANDOM STUDY DESIGN



0 200 400 Feet

Virginia Pollinator-Smart Solar Industry
Example of Stratified-Random Study Design
0 200 400 feet

Appendix B

Virginia Pollinator-Smart Rapid Assessment Form

COMPLETE THIS PAGE FOR EACH SAMPLING PLOT

GENERAL INFORMATION

Plot Code/Identifier:	Project:
Zone:	Surveyors:
Date:	

COMMUNITY NAME

OBSERVATION AREA *[100 m² circular plot recommended for woody plants; 1 m² plot recommended for herbaceous species]*

Circle of radius m; or m by m; or area =

PLOT DOCUMENTATION	GPS DATA *[Decimal Degrees]*
# of Photos: ☐ No Photos Taken	GPS Unit: GPS Datum:
Photo Descriptions:	LAT: LONG:

GENERAL NOTES

USE THIS PAGE TO ASSESS SAMPLING ADEQUACY ON-THE-FLY

SPECIES AREA CURVE

NUMBER OF PLOTS SAMPLED

CUMULATIVE SPECIES RICHNESS

SPECIES COMPOSITION AND ABUNDANCE

List all plant species within your observation area and indicate relative abundance.

PLOT ID:

Zone: *[P = panel, S = screen, O = open area]*														
Habitat: *[H = herbaceous, SS = scrub-shrub, F = forested, W = wetland, O = other*]*														
Ground														
% Bare Ground														
% Rock														
Taxon														

SPECIES COMPOSITION AND ABUNDANCE

List all plant species within your observation area and indicate relative abundance.

PLOT ID:

Zone: *[P = panel, S = screen, O = open area]*														
Habitat: *[H = herbaceous, SS = scrub-shrub, F = forested, W = wetland, O = other*]*														
Ground														
% Bare Ground														
% Rock														
Taxon														

Appendix C

Completed Vegetation Data Table

VEGETATION MONITORING DATA

Sample Solar Site Facility | Establishment Year 2 (2019)

					PANEL ZONE														
SCIENTIFIC NAME	**COMMON NAME**	**SPF?**	**FLOWERING PERIOD***	**INV SPP**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**
Bare Ground						15.0										0.5			
Achillea millefolium	Common Yarrow	Y	S, ES, LS, F						15.0										
Amaranthus hybridus	Slender Pigweed	N	N/A																
Ambrosia artemisiifolia	Annual Ragweed	Y	LS, F		15.0	63.0	38.0			63.0	38.0	3.0	38.0	85.0	15.0	63.0	15.0	38.0	38.0
Andropogon virginicus	Broom-Sedge	Y	N/A			38.0			38.0		0.5	15.0		3.0					63.0
Apocynum cannibinum	Indian Hemp	Y	S, ES, LS																
Bromus racemosus	Bald Brome	N	N/A																
Cirsium arvense	Canadian Thistle	N	N/A	✓		15.0													
Conyza canadensis	Horseweed	Y	ES, LS, F		15.0		63.0	15.0			63.0	3.0	15.0	38.0	15.0	38.0	38.0	38.0	
Dactylis glomerata	Orchard Grass	N	N/A		0.5														38.0
Daucus carota	Queen Anne's-Lace	N	N/A																
Dichanthelium clandestinum	Deer-Tongue Rosette Grass	Y	N/A																
Dichanthelium dichotomum	Cypress Rosette Grass	Y	N/A														38.0		
Digitaria ciliaris	Southern Crab Grass	N	N/A																
Digitaria ischaemum	Smooth Crabgrass	N	N/A			15.0													
Eragrostis hirsuta	Big-top Lovegrass	Y	N/A				3.0												
Eragrostis spectabilis	Purple Lovegrass	Y	N/A																
Eupatorium capillifolium	Dog-Fennel	Y	LS, F						3.0		38.0					3.0	3.0		
Juncus effusus	Lamp Rush	Y	N/A																
Juncus tenuis	Lesser Poverty Rush	Y	N/A						3.0			0.5							
Lespedeza cuneata	Chinese Bush-Clover	N	N/A	✓			15.0		15.0										
Lespedeza frutescens	Shrubby Lespedeza	Y	ES, LS, F						15.0										
Lespedeza procumbens	Trailing Lespedeza	Y	ES, LS, F						63.0										15.0
Lespedeza repens	Creeping lespedeza	Y	S, ES, LS, F																
Lobelia inflata	Indian-tobacco	Y	ES, LS, F																
Lonicera japonica	Japanese Honeysuckle	N	N/A	✓								0.5							
Oxalis stricta	Upright Yellow Wood-Sorrel	Y	S, ES, LS, F			3.0											3.0		
Panicum virgatum	Wand Panic Grass	Y	N/A							38.0									
Persicaria longiseta	Bristly Lady's Thumb	N	N/A	✓															
Physalis heterophylla	Clammy Ground-Cherry	Y	S, ES, LS												3.0				
Phytolacca americana	American Pokeweed	Y	S, ES, LS, F																
Plantago lanceolata	English Plantain	N	N/A									3.0					0.5		
Potentilla indica	Indian-Strawberry	N	N/A																
Pseudognaphalium obtusifolium	Sweet Everlasting	Y	LS, F											3.0		3.0	3.0	3.0	
Rubus flagellaris	Whiplash Dewberry	Y	S, ES																
Rubus pensilvanicus	Pennsylvania Blackberry	Y	S, ES						3.0			0.5						3.0	
Rudbeckia hirta	Black Eyed-Susan	Y	S, ES, LS						0.5	3.0	3.0								
Schedonorus arundinaceus	Tall False Rye Grass	N	N/A																

VEGETATION MONITORING DATA *CONT...*

Sample Solar Site Facility | Establishment Year 2 (2019)

SCIENTIFIC NAME	COMMON NAME	SPF?	FLOWERING PERIOD*	INV SPP	PANEL ZONE														
					P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
Solanum carolinense	Carolina Horse-Nettle	Y	S, ES, LS									15.0			38.0				
Solanum ptycanthum	Eastern Black Nightshade	Y	S, ES, LS, F																
Solidago altissima	Tall Goldenrod	Y	LS, F					38.0	3.0			15.0				15.0			
Solidago rugosa	Rough-leaved Goldenrod	Y	LS, F																
Stellaria media	Common Chickweed	N	N/A	✓															
Symphoricarpos orbiculatus	Coral-Berry	Y	N/A																
Symphyotrichum lateriflorum	Farewell-Summer	Y	LS, F																
Taraxacum officinale	Common Dandelion	N	N/A		7.5														
Thlaspi arvense	Field Pennycress	N	N/A									0.5						15.0	
Tridens flavus	Tall Redtop	Y	N/A				38.0												
Trifolium arvense	Rabbit-foot Clover	N	N/A											15.0					
Trifolium repens	White Clover	N	N/A		63.0		38.0	38.0		15.0	15.0	38.0	86.0	15.0	63.0	3.0	63.0	38.0	
Ulmus rubra	Slippery Elm	Y	N/A		0.5	15.0		0.5	0.5								0.5	3.0	
Verbascum thapsus	Great Mullein	N	N/A				15.0					38.0		3.0			15.0		
Verbena brasiliensis	Brazilian Vervain	N	N/A					63.0								15.0			

% Cover of Solar Native Plant Finder Species	**99.6**
Total Number of Native Plant Finder Species	**20**
Total Number of Native Grass Species	**5**
% Cover of Invasive Species	**3**
% Cover of Fescue	**0**
Flowering Phenologies	**S= 6, ES=9, LS=11, F=9**

***S=Spring, ES=Early Summer, LS=Late Summer, F=Fall**

VEGETATION MONITORING DATA *CONT...*

		OPEN AREA									SCREENING ZONE											
SCIENTIFIC NAME	**COMMON NAME**	**O1**	**O2**	**O3**	**O4**	**O5**	**O6**	**O7**	**O8**	**O9**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**
Bare Ground																			15.0			
Achillea millefolium	Common Yarrow												0.5						3.0			
Amaranthus hybridus	Slender Pigweed										63.0	63.0										
Ambrosia artemisiifolia	Annual Ragweed	15.0			38.0	63.0	38.0	38.0	63.0	38.0											15.0	
Andropogon virginicus	Broom-Sedge	3.0				3.0	15.0		15.0	15.0			15.0		15.0					3.0		15.0
Apocynum cannibinum	Indian Hemp						15.0															
Bromus racemosus	Bald Brome						0.5		3.0	38.0												
Cirsium arvense	Canadian Thistle																		15.0		15.0	
Conyza canadensis	Horseweed	85.0	15.0	63.0	63.0	38.0		38.0	15.0					63.0	38.0	63.0	63.0	63.0	63.0		38.0	
Dactylis glomerata	Orchard Grass						15.0								15.0			15.0				15.0
Daucus carota	Queen Anne's-Lace												15.0									
Dichanthelium clandestinum	Deer-Tongue Rosette Grass																15.0					
Dichanthelium dichotomum	Cypress Rosette Grass															3.0	3.0					
Digitaria ciliaris	Southern Crab Grass										63.0											
Digitaria ischaemum	Smooth Crabgrass					38.0	15.0		38.0	63.0												
Eragrostis hirsuta	Big-top Lovegrass			38.0								15.0										
Eragrostis spectabilis	Purple Lovegrass								15.0													
Eupatorium capillifolium	Dog-Fennel				3.0	0.5							0.5	15.0				15.0	3.0	3.0		38.0
Juncus effusus	Lamp Rush																			38.0		
Juncus tenuis	Lesser Poverty Rush			3.0	3.0				0.5												3.0	15.0
Lespedeza cuneata	Chinese Bush-Clover																					
Lespedeza frutescens	Shrubby Lespedeza																					
Lespedeza procumbens	Trailing Lespedeza																					
Lespedeza repens	Creeping lespedeza												15.0			3.0					3.0	
Lobelia inflata	Indian-tobacco			3.0										15.0								
Lonicera japonica	Japanese Honeysuckle												38.0									
Oxalis stricta	Upright Yellow Wood-Sorrel					3.0	0.5		3.0													15.0
Panicum virgatum	Wand Panic Grass																					
Persicaria longiseta	Bristly Lady's Thumb				15.0																	
Physalis heterophylla	Clammy Ground-Cherry																					
Phytolacca americana	American Pokeweed										38.0						38.0					
Plantago lanceolata	English Plantain																	15.0				
Potentilla indica	Indian-Strawberry																		15.0			
Pseudognaphalium obtusifolium	Sweet Everlasting				15.0					15.0										3.0	15.0	
Rubus flagellaris	Whiplash Dewberry												15.0			15.0	15.0					
Rubus pensilvanicus	Pennsylvania Blackberry	15.0																	0.5			
Rudbeckia hirta	Black Eyed-Susan														63.0						15.0	
Schedonorus arundinaceus	Tall False Rye Grass									15.0			38.0									

VEGETATION MONITORING DATA *CONT...*

		OPEN AREA									SCREENING ZONE											
SCIENTIFIC NAME	**COMMON NAME**	**O1**	**O2**	**O3**	**O4**	**O5**	**O6**	**O7**	**O8**	**O9**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**
Solanum carolinense	Carolina Horse-Nettle												3.0				38.0					3.0
Solanum ptycanthum	Eastern Black Nightshade	38.0																				
Solidago altissima	Tall Goldenrod											15.0		15.0			15.0					
Solidago rugosa	Rough-leaved Goldenrod		15.0			0.5	38.0															
Stellaria media	Common Chickweed	63.0																				
Symphoricarpos orbiculatus	Coral-Berry						15.0															
Symphyotrichum lateriflorum	Farewell-Summer	15.0																				
Taraxacum officinale	Common Dandelion					3.0				3.0		3.0		15.0				3.0			15.0	
Thlaspi arvense	Field Pennycress																					
Tridens flavus	Tall Redtop				0.5				15.0						15.0							15.0
Trifolium arvense	Rabbit-foot Clover																					
Trifolium repens	White Clover	15.0	98.0	38.0	85.0			85.0		38.0		15.0		15.0	15.0					85.0	15.0	38.0
Ulmus rubra	Slippery Elm							3.0	15.0													
Verbascum thapsus	Great Mullein	18		3.0	15.0			15.0								15.0		3.0	38.0		3.0	
Verbena brasiliensis	Brazilian Vervain																					
% Cover of Solar Native Plant Finder Species		**105.4**									**84.3**											
Total Number of Native Plant Finder Species		**18**									**22**											
Total Number of Native Grass Species		**4**									**5**											
% Cover of Invasive Species		**8.7**									**5.7**											
% Cover of Fescue		**1.7**									**3.2**											
Flowering Phenologies		**S= 3, ES=6, LS=10, F=9**									**S= 8, ES=10, LS=11, F=10**											

***S=Spring, ES=Early Summer, LS=Late Summer, F=Fall**

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